22.5W OUTPUT STEP-DOWN CONVERTER with FAST CHARGE PROTOCOLS (DCP/QC2.0/QC3.0/FCP/AFC/SFCP/MTK/SCP/VOOC)

1 Features

- **Synchronous step-down converter**
  - Built-in Power MOSFETs
  - Input Voltage Range, 5.2V to 32V
  - Output voltage range: 3V~12V, adjustable according to the fast charge protocol
  - QC output power: 18W max. (5V@3.4A, 9V@2A, 12V@1.5A)
  - SCP Maximum Output Power: 22.5W Maximum
  - Output Current Limit Protection
  - VIN=24V,VOUT=5V/3A,Conversion efficiency up to 94.2%
  - Soft-Start
  - Output voltage line compensate: 50mV/A
- **Fast Charge Protocols**
  - Supports DCP (BC1.2 and Apple)
  - Supports QC3.0 and QC2.0
  - Supports Huawei Fast charge: FCP and SCP
  - Supports Samsung Fast Charge Protocol AFC(MAX 12V)
  - Support MTK PE+2.0 and PE+ 1.1
  - Support SFCP
  - Support OPPO fast charge: VOOC
- **Multiple Safety Protections**
  - Input Over-Current Protection, Output Over-Current Protection ,Input Over/Under Voltage Protection, Short Circuit Protection
  - Over Temperature Protection
  - DP/DM Over Voltage Protection
  - ESD 4KV, Input Voltage Withstand up to 40V

2 Application

- **Car Charger**
- **Fast Charge Adapter**
- **Intelligent Power Hub**

3 Introduction

IP6525S is a synchronized switch buck regulator and support multiple fast charge output standards, providing solutions for car charger, fast charge adaptor and smart power strip.

IP6525S has built-in power MOSFET, input voltage range is 5.2V to 32V, output voltage ranges from 3V to 12V, and output voltage range with 22.5W max. output power; support voltage and current auto adjust according to the fast charge standard. Typical output voltage and current including: 5V@3A, 9V@2A, 12V@1.5A.

IP6525S has the function of automatic adjustment of overcurrent point. When SCP low voltage fast charging protocol handshake is successful, Supports 5V@4.5A, 4.5V@5A.

IP6525S supports output line compensation, when output current increases, the output voltage will increase accordingly that makes up the resistive voltage drop introduced by connection, wire, and PCB traces.

IP6525SS incorporates soft-start function to prevent the inrush current during start-up.

IP6525S supports multiple fast charge protocols. The protocol is identified by the signal on DP/DM, and IP6525S adjusts output voltage according to the corresponding protocols. IP6525S supports DCP (BC1.2 and Apple), Qualcomm Quick Charge QC2.0 and QC3.0, Huawei FCP ,Samsung AFC(MAX 12V), SFCP, MTK PE+2.0 and PE+ 1.1 and OPPO fast charge: VOOC

IP6525S support multi-protection on input overvoltage and under voltage, output overcurrent, overvoltage, under voltage and short circuit.

The package of IP6525S is ESOP8.

4 IP6525S Series Product Introduction

IP6525S	USBA	QC(1)	5V/3A	9V/2A	12V/1.5A	HLED function: If this function is not required, This PIN floats.
IP6525S_EN	USBA	QC(1)	5V/3A	9V/2A	12V/1.5A	EN function: If this function is not required, This PIN floats.
IP6525S_PS	USBA	QC(1)	5V/3A	9V/2A	12V/1.5A	PS function: If this function is not required, This PIN is grounded.

Notes:

- QC represents the output power of high voltage fast charge.
- IP6525S supports SCP low voltage fast charging protocol, supports 5V@4.5A, 4.5V@5A.
- QC fast charge output of IP6525S supports CV/CP/CC loop.

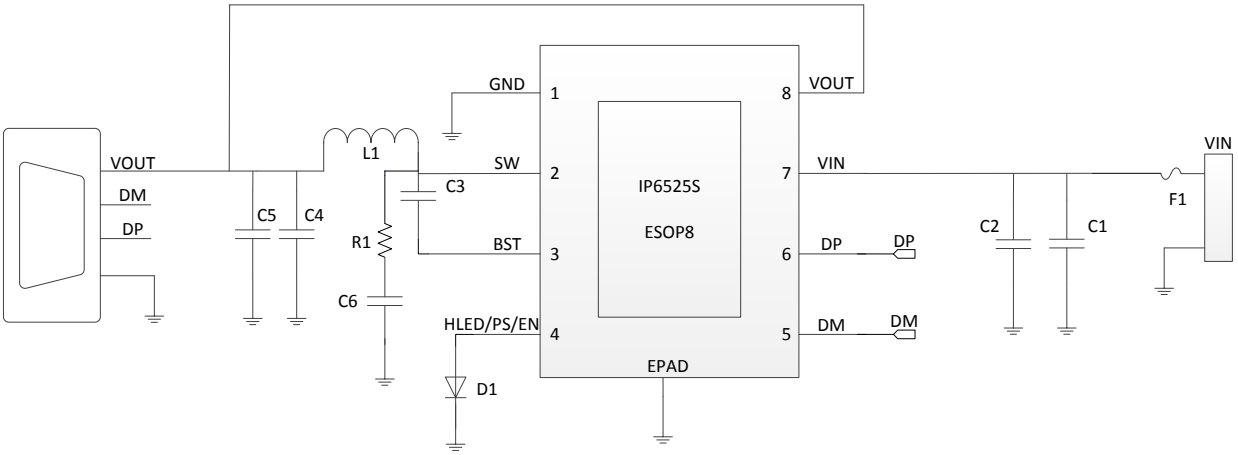


Fig. 1 Simplified Application Schematic

5 PIN Definition

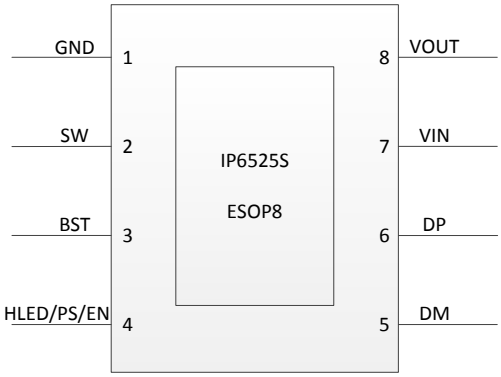


Fig. 2 IP6525S PIN Configuration

NO.	Name	Description
1	GND	Power ground
2	SW	Switching node of the DC-DC converter
3	BST	Bootstrap capacitor node
4	HLED/PS/EN	Fast charge LED indication/ power control function/chip enable(EN function needs to be customed)
5	DM	USB DM terminal for fast charge protocol
6	DP	USB DP terminal for fast charge protocol
7	VIN	Input voltage node
8	VOUT	Output voltage feedback node
9(EPAD)	GND	Power and thermal ground

6 Absolute Maximum Ratings

Parameters	Symbol	Value	Unit
Input voltage range	V_{IN}	-0.3 ~ 40	V
SW voltage range	V_{SW}	-0.3 ~ 40	V
DM/DP voltage range	$V_{DM/DP}$	-0.3 ~ 6	V
VOUT voltage range	$V_{VSP/VSN}$	-0.3 ~ 20	V
Junction Temp range	T_J	-40 ~ 150	℃
Storage Temp range	Tstg	-60 ~ 150	℃
Thermal resistance (junction to ambient)	θ_{JA}	40	℃/W
ESD（HBM）	ESD	4	KV

* Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to Absolute Maximum Rated conditions for extended periods may affect device reliability.

7 Recommended Operating Conditions

Parameter	Symbol	Min.	Typ.	Max.	Unit
Input voltage	V_{IN}	5.2	12/24	32	V

*Devices' performance cannot be guaranteed when working beyond those Recommended Operating Conditions

8 Electrical Charateristics

TA=25℃，L=22uH，C_{OUT}=100uF E-cap(About 40mΩ ESR)，VIN=12V，VOUT=5V, otherwise specified

Parameters	Symbol	Test Condition	Min.	Typ.	Max	Unit
Input system						
Input voltage	V_{IN}		5.2	12	32	V
Input under voltage	V_{IN-UV}	Rising voltage		5.2		V
		Falling voltage		5.0		V
Input over voltage	V_{IN-OV}	Rising voltage		32.6		V
		Falling voltage		32.1		V
Input quiescent current	I_Q	VIN=12V, VOUT=5V/0A	--	3	--	mA
Power system						
High-side MOS Ron resistance	$R_{DS(ON)}$		--	30	--	mΩ
Low-side MOS Ron resistance	$R_{DS(ON)}$		--	20	--	mΩ
Switching frequency	F_S		--	100	--	KHz
Output system						
Output voltage	V_{OUT}		3	5	12	V
Output voltage ripple	ΔV_{OUT}	VIN=12V, VOUT=5V/3A COUT: 220uF+22uF		85		mV
		VIN=12V, VOUT=9V/3A COUT: 220uF+22uF		70		mV
		VIN=24V, VOUT=12V/2.25A COUT: 220uF+22uF		90		mV
Soft start time	T_{SS}	VIN=12V, VOUT=5V	--	4	--	ms
Output line compensate voltage	V_{COMP}	VIN=12V, VOUT=5V, IOUT=3A	--	150	--	mV
Single port max output current in CC mode	I_{OUT}	VIN=12V, VOUT<=4V	--	3.4	--	A
		VIN=12V, 4V<VOUT<=5V	--	3.4	--	A
		VIN=12V, 7V<VOUT<=9V	--	2	--	A
		VIN=24V, 9V<VOUT<=12V	--	1.5	--	A
Output hiccup restart voltage	V_{OUT}	Hiccup restart voltage when output enter CC mode (VOUT preset voltage >= 5V)	--	4.1	--	V

		Hiccup restart voltage when output enter CC mode (VOUT preset voltage < 5V)	--	3	--	V
Output hiccup restart time	T_{HIC}	VIN=12V, VOUT=5V	--	2	--	S
DPDM over voltage protection voltage	V_{OVP_DPDM}	VIN=12V, VOUT=5V	--	4.5	--	V
Thermal shutdown temperature	T_{OTP}	Rising temperature	--	150	--	℃
Thermal shutdown temperature hysteresis	ΔT_{OTP}		--	40	--	℃

9 Function Description

9.1 IP6525S Internal block diagram

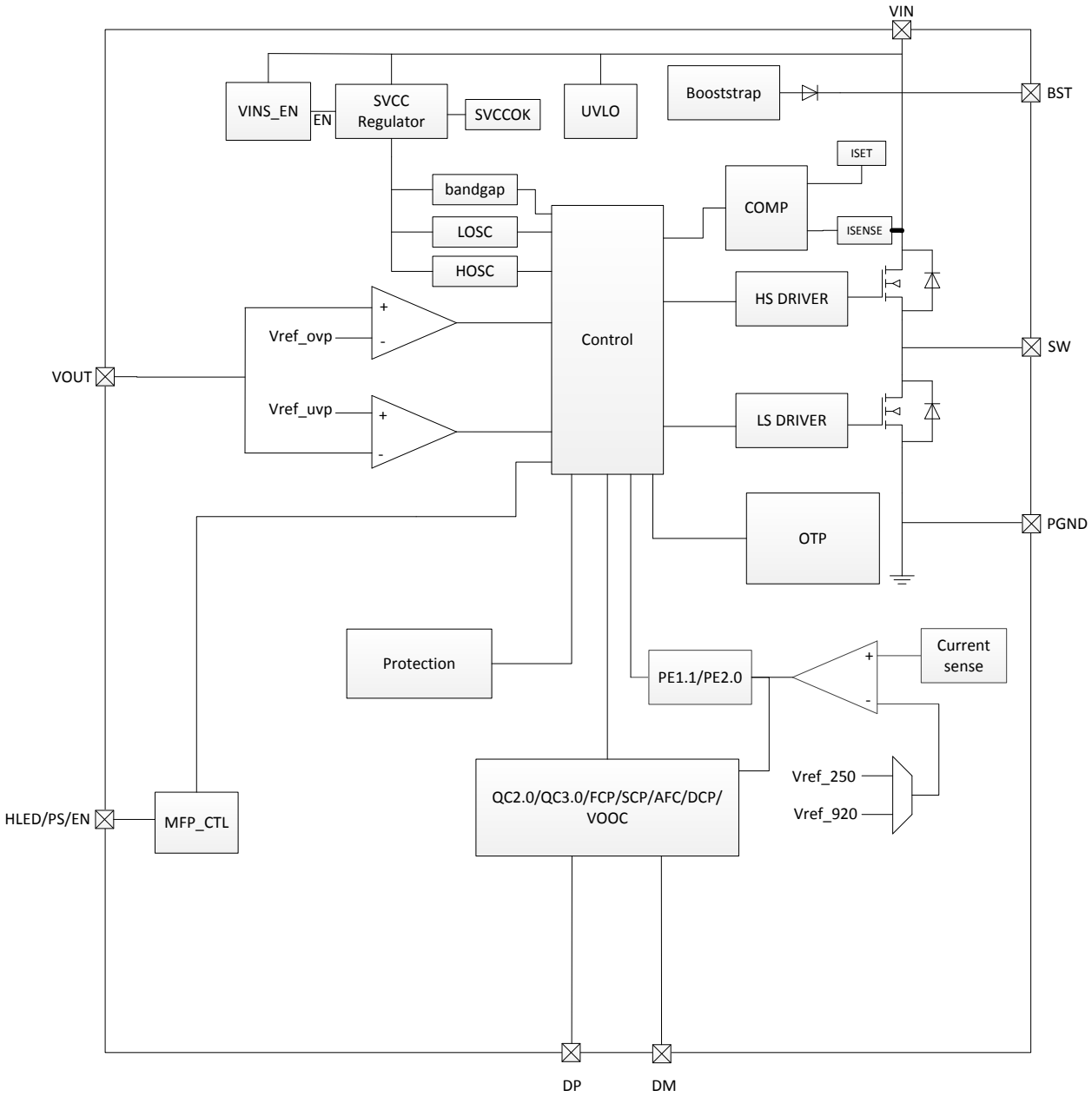


Figure 3 IP6525S Internal block diagram

9.2 Synchronized switch buck regulator

IP6525S integrate a Synchronous-Rectified Buck Converter, input voltage range is 5.2V~12V, output voltage range is 3V~20V, Typical output portfolio is 5V@3.4A, 9V@2A and 12V@1.5A.

IP6525S integrate power switch MOSFET with 100kHz working frequency. The conversion efficiency is up to 94.2% at VIN=24V, VOUT=5V@3A. The efficiency under different input voltage and load current is shown in Fig. 4. Fig. 5 show the output voltage characteristics under different load current.

IP6525S auto adjust output voltage and current according to the fast charge requirement.

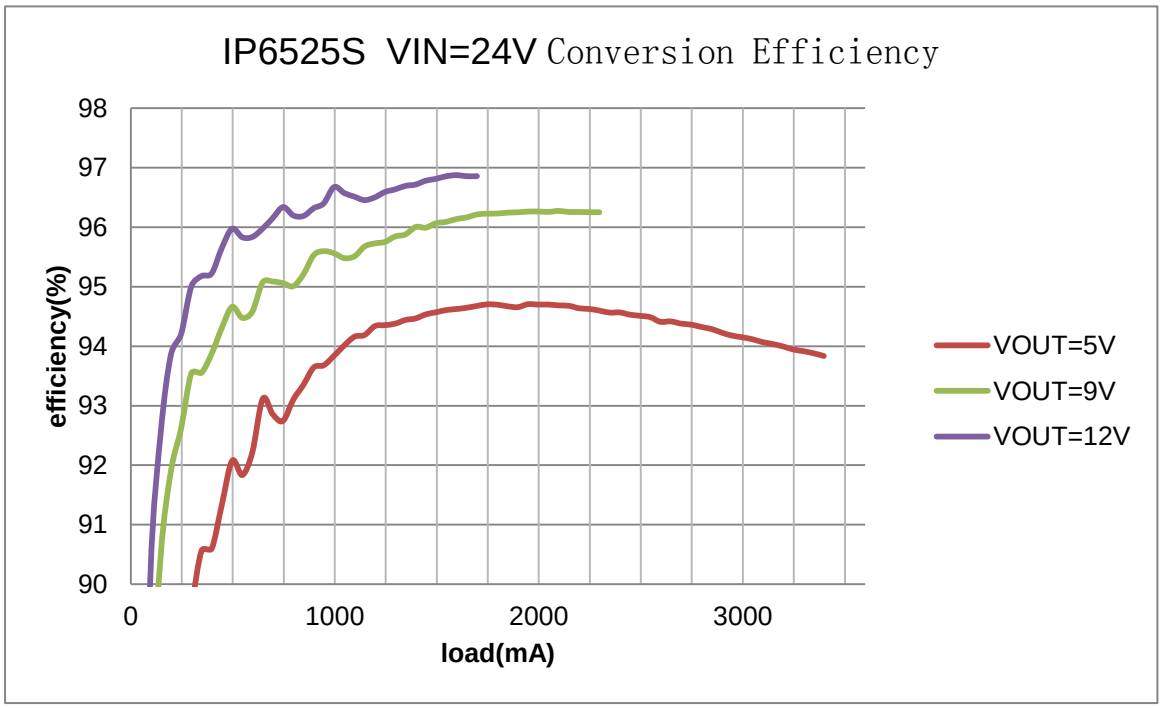


Fig. 4 IP6525S Conversion Efficiency

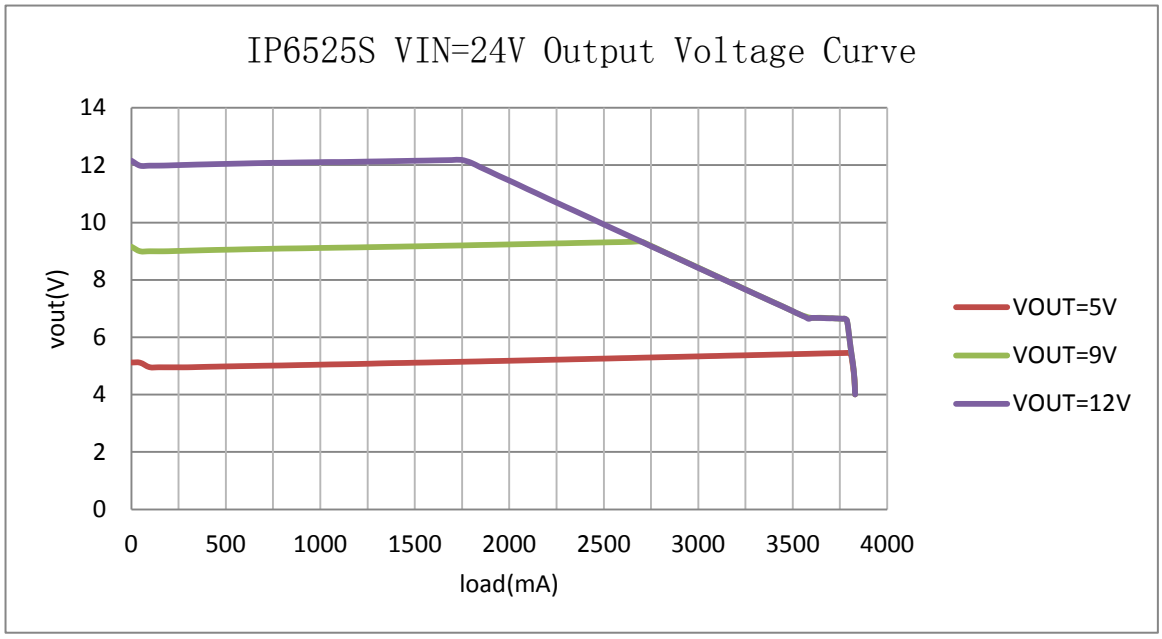


Fig.5 IP6525S Vout-Iout curve when VIN=24V

9.3 Output Voltage Line Loss Compensation

IP6525S supports output line loss compensation. The output voltage increases at 100mV/1A rate.

9.4 PIN4 Function

PIN-4(HLED/PS/EN) can be alternatively used as fast charge indication, Control power function , external chip enable function.

PIN-4 is used as fast charge indication. Indication led can be direct connected to this PIN. LED turns on when the fast charge protocol request voltage level higher than 5V.

When used as a power control function, two IP6525S_PS can be used to the scheme of realizing input power sharing dual A-Port output; It can also form an AC two-port output scheme with IP6537.

When used as a power control function, pulling down PIN-4 will shut down DC-DC converter. PIN-4 cannot be connected to VIN, or else PIN-4 will be damaged by high voltage.

9.5 CC/CV Characteristics

IP6525S output has CV/CP/CC mode: when the output current is lower than preset value, the output is in CV mode with constant voltage; when the output current is higher than preset value, the output is in CP mode with decreasing output voltage. as the load increases, the output voltage decreases; when the voltage drops to 6.5V, CC mode is entered, The load continues to increase and the output voltage rapidly decreases until the output voltage undervoltage protection is triggered.

9.6 Protections

IP6525S monitors voltage on VIN. If the voltage is lower than 5.0V, IP6525S enters standby mode, and shuts down the converter. If the voltage is higher than 32.6V, IP6525S detects over voltage, and then shuts down the converter. when VIN decrease under 32.1V, IP6525S determines the input voltage recovers and opens the output.

IP6525S support output under voltage protection: when VOUT voltage is lower or equals 5V, if the VOUT voltage is lower than 4.1V, IP6525S determines the output is under voltage and will shut down the output and hiccup restart after 2sec.

IP6525S support short circuit protect, 8ms after the circuit is started, if VOUT voltage is under 4.1V, IP6525S determines the output is short circuit and will shut down the output and hiccup restart after 2sec.

IP6525S support DP/DM over voltage protection, when the DP/DM voltage is higher than 4.5V, IP6525S determines the signals are over voltage and will shut down the output and hiccup restart after 2sec.

IP6525S support over temperature protection: when the temperature detected is higher than 150℃, the output will be shut down. When the temperature decreases below 110℃, IP6525S determines the temperature has recovered and will restart the output.

9.7 Fast Charge Protocols

IP6525S supports multiple fast charge protocols：

- DCP (BC1.2 and Apple)
- Qualcomm quick charge QC2.0 and QC3.0
- Huawei FCP and SCP
- Samsung AFC(MAX 12V)
- Support MTK PE+1.1 and MTK PE+2.0
- Support SFCP
- Support OPPO fast charge : VOOC

Note:

1. IP6525S/IP6525S_EN/IP6525S_PS does not support VOOC protocol;
2. The customer can apply for the customized device that supports the VOOC protocol after obtaining the VOOC authorization;

10 Typical Application

IP6525S car charging solution only needs MOSFET, inductor, capacitor and resistor.

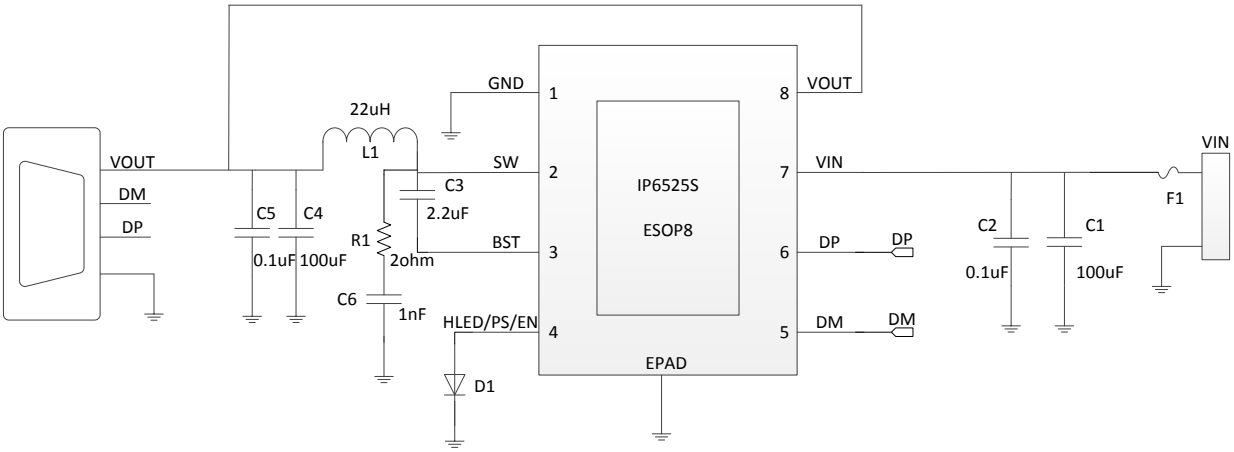


Fig. 6 IP6525S Application Schematic

Notes:

1. IP6525S EPAD must have a good contact with PCB GND;
2. PIN4 should not be connected anywhere if the HLED indicator light is not needed;
3. C1 and C2 should be placed close to the PIN7 of IP6525S;
4. C5 should be placed close to the PIN8 of IP6525S;
5. R1 and C6 should be placed close to the PIN2 of IP6525S, the loop composed of SW(PIN2), R1, C6 and GND should be minimized on the PCB board;

11 BOM

NO.	Device	Spec.	Unit	Counts	Designator	备注
1	IC	IP6525S	PCS	1	U1	
2	electrolytic capacitor	100uF/35V	PCS	1	C1	Rated voltage>35V.
3	electrolytic capacitor	100uF/25V	PCS	1	C4	Rated voltage>25V
4	TC-220M-4.5A-CS137125	22uH+/-20%，Nominal current 4.5A DCR<12mohm	PCS	1	L1	3L Electronic
5	ceramic capacitor	0603 2.2uF 10%	PCS	1	C3	Rated voltage>16V
6	ceramic capacitor	0603 100nF 10%	PCS	1	C2	Rated voltage>35V. Close to IC PIN.
7	ceramic capacitor	0603 100nF 10%	PCS	1	C5	Rated voltage>16V
8	resistor	0603 2ohm 5%	PCS	1	R1	
9	ceramic capacitor	0603 1nF 10%	PCS	1	C6	
10	LED	0603	PCS	1	D1	
11	fuse	F1	PCS	1	F1	Nominal current>4A

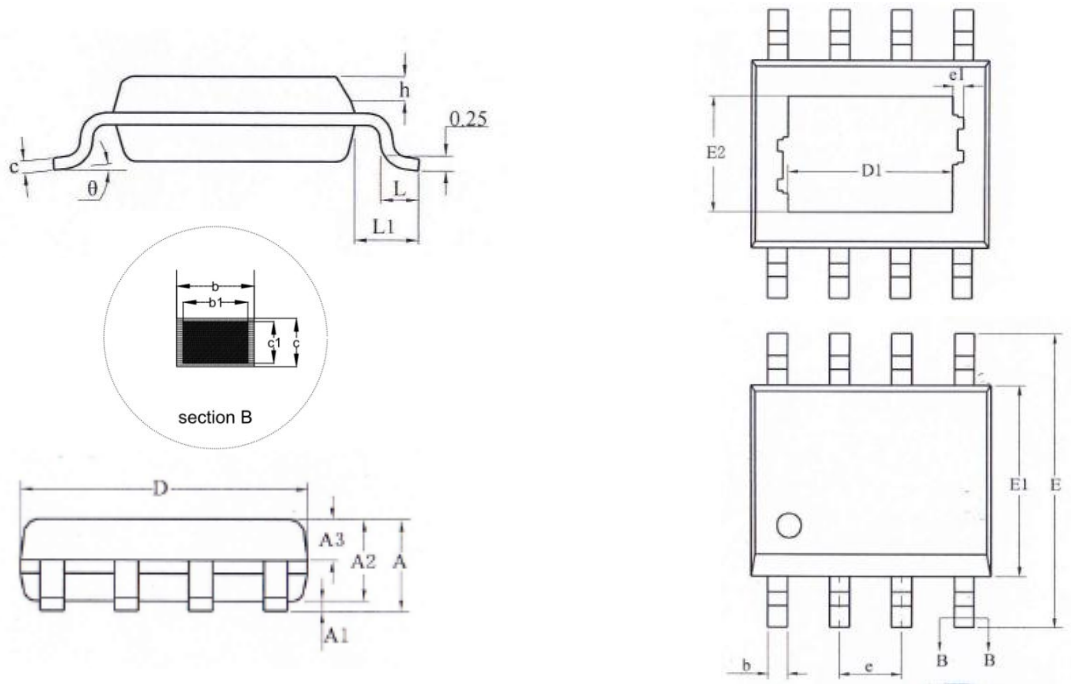
Recommended inductor: TC-220M-4.5A-CS137125

3L product No.	Inductance (uH)	Tolerance	DC Resistance (mΩ)		Heat Rating Current DC Amp.	Saturation Current DC Amps.	Measuring Condition
			Typ.	Max.	Idc(A)Max	Isat(A)Max	
TC-220M-4.5A-CS137125	22.0	±20%	12	14	4.5	8	

12 IP series IC Products List

IC Part	Output Current	Dual Ports	Protocols										Package	
			DCP	QC2.0	QC3.0	FCP	SCP	AFC	MTK PE	SFCP	PD2.0	PD3.0 (PPS)	Pkg	P2P
IP6523S_N	3.4A	–	√	–	–	–	–	–	–	–	–	–	ESOP8	PIN2PIN
IP6536	2.4A	√	√	–	–	–	–	–	–	–	–	–	ESOP8	
IP6525T	18W	–	√	√	√	√	–	√	–	–	–	–	ESOP8	PIN2PIN
IP6525S	18W	–	√	√	√	√	√	√	√	√	–	–	ESOP8	
IP6510	18W	–	√	√	√	√	–	√	–	–	√	–	ESOP8	PIN2PIN
IP6520	18W	–	√	√	√	√	√	√	√	–	√	–	ESOP8	
IP6520_PPS	18W	–	√	√	√	√	√	√	√	–	√	√	ESOP8	
IP6537_C	18W	–	√	√	√	√	√	√	√	√	√	√	QFN24	PIN2PIN
IP6537_C_30W20V	30W	–	√	√	√	√	√	√	√	√	√	√	QFN24	
IP6515	4.8A	√	√	–	–	–	–	–	–	–	–	–	QFN32	
IP6538_CC	27W	√	√	√	√	√	–	√	√	–	√	√	QFN32	PIN2PIN
IP6538_AC	27W	√	√	√	√	√	√	√	√	–	√	√	QFN32	
IP6538_AA	24W	√	√	√	√	√	√	√	√	–	–	–	QFN32	
IP6527S_A	24W	–	√	√	√	√	√	√	√	–	–	–	QFN32	PIN2PIN
IP6527S_C	27W	–	√	√	√	√	–	√	√	–	√	√	QFN32	
IP6527S_C_18WPD	18W	–	√	√	√	√	–	√	√	–	√	√	QFN32	

13 Package



SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	--	--	1.65
A1	0.05	--	0.15
A2	1.30	1.40	1.50
A3	0.60	0.65	0.70
b	0.39	--	0.47
b1	0.38	0.41	0.44
c	0.20	--	0.24
c1	0.19	0.20	0.21
D	4.80	4.90	5.00
E	5.80	6.00	6.20
E1	3.80	3.90	4.00
e	1.27BSC		
h	0.25	--	0.50
L	0.50	0.60	0.80
L1	1.05REF		
θ	0	--	8°
D1	--	3.10REF	--
E2	--	2.21REF	--

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